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Pai et al.

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(54) **DIGITAL SUBSCRIBER LINE/HOME PHONELINE NETWORK ROUTER**

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(52) **U.S. Cl.** **370/257**; 370/352; 370/401; 370/466; 370/469; 710/313; 375/222

(58) **Field of Search** 370/401, 402, 370/466, 467, 469, 355, 484, 445, 465, 257, 236, 463, 493, 356; 455/560; 375/221, 222; 710/313

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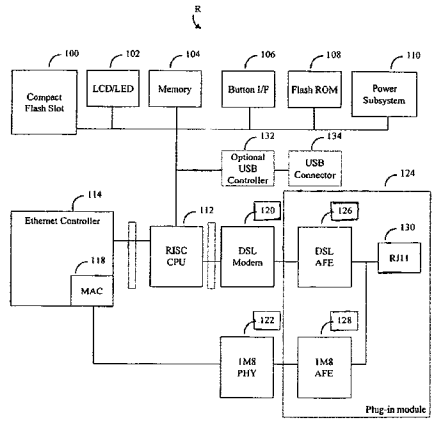
(57) **ABSTRACT**

A digital subscriber line (DSL)/home phoneline network router provides DSL connectivity and home networking support. The router provides a single phoneline connection (RJ-11 jack) to access either the Internet or a home phoneline network. In terms of hardware, the router may include a central processing unit, a DSL modem, and a home phoneline networking device (media access controller and home phoneline networking physical interface). In terms of software, the router may include a DSL driver, a local area network (LAN) driver, a media access controller driver, network routing stacks and a real time operating system.

18 Claims, 4 Drawing Sheets



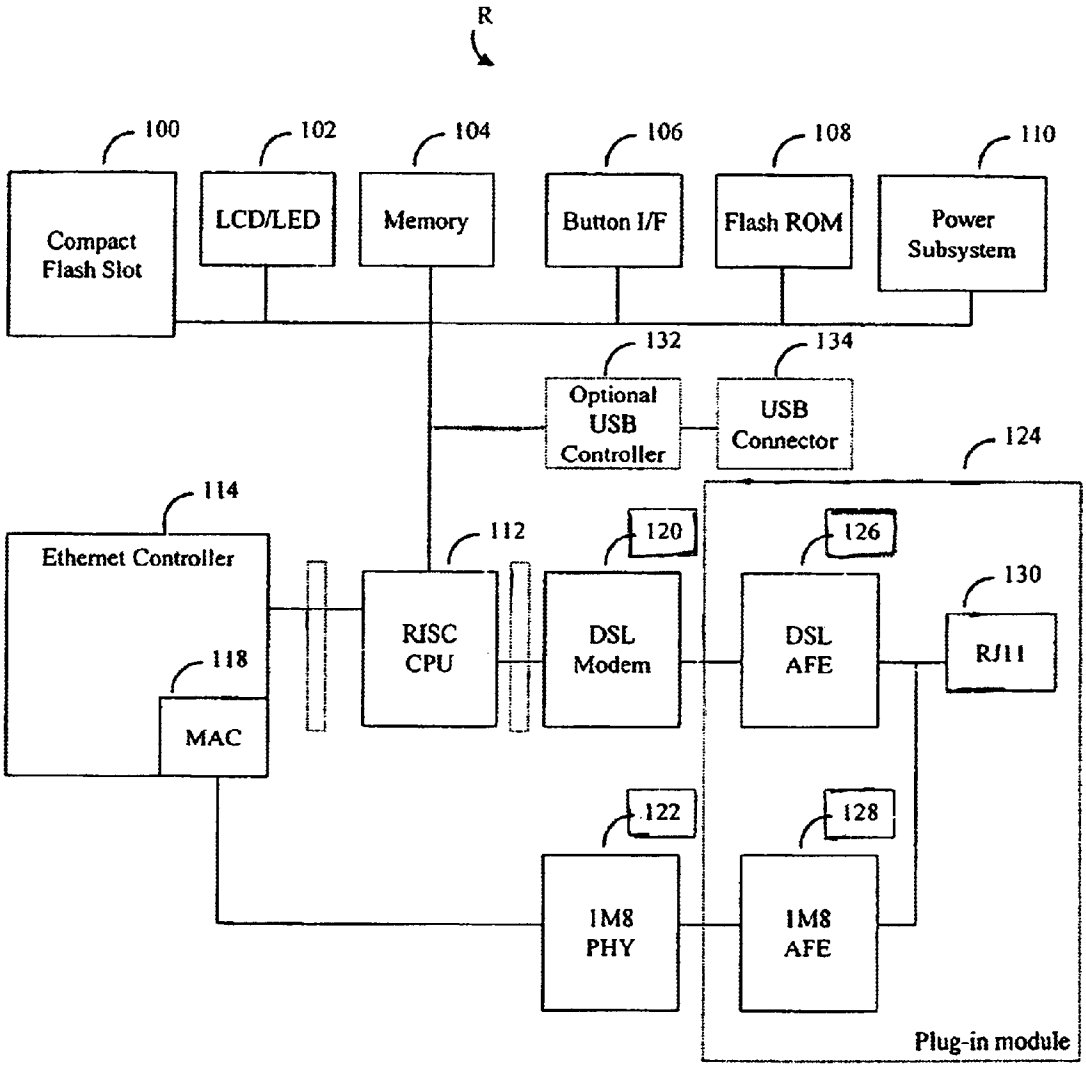

R
100
Compact Flash Slot
102
LCD/LED
104
Memory
106
Button I/F
108
Flash ROM
110
Power Subsystem
132
Optional USB Controller
134
USB Connector
124
114
Ethernet Controller
112
120
126
130
RISC CPU
DSL Modem
DSL AFE
RJ11
118
MAC
122
128
1M8 PHY
1M8 AFE
Plug-in module

Figure 1

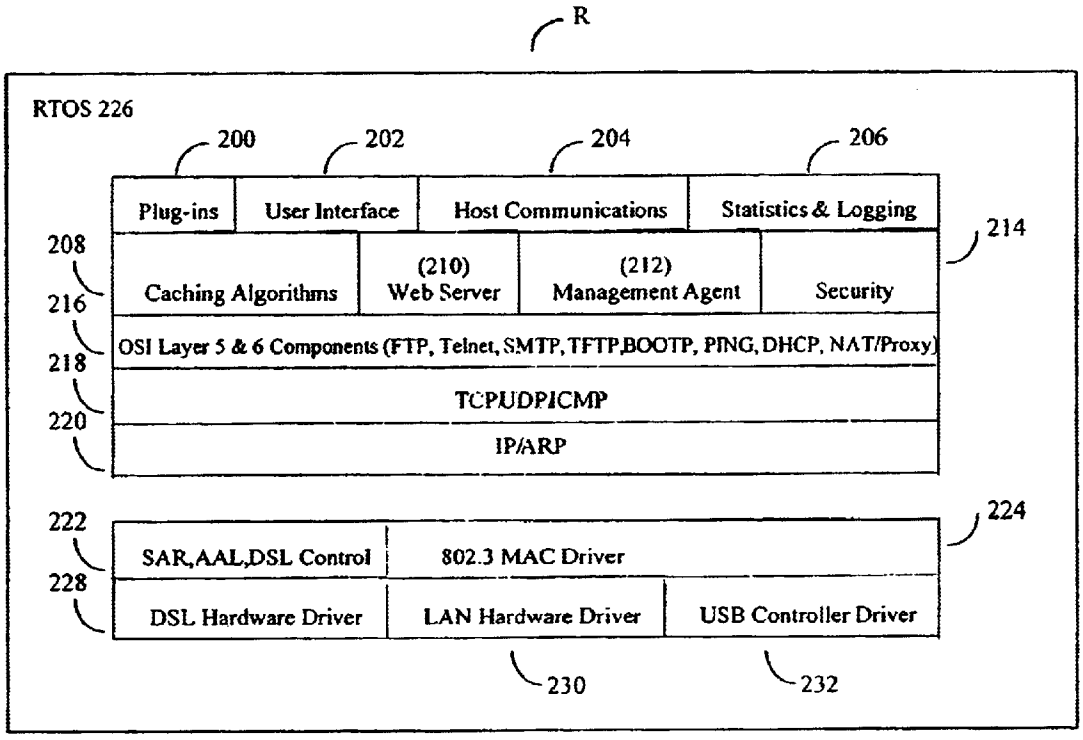

R
RTOS 226
200
202
204
206
Plug-ins
User Interface
Host Communications
Statistics & Logging
214
208
Caching Algorithms
(210)
Web Server
(212)
Management Agent
Security
216
OSI Layer 5 & 6 Components (FTP, Telnet, SMTP, TFTP,BOOTP, PING, DHCP, NAT/Proxy)
218
TCP/UDP/ICMP
220
IP/ARP
222
224
SAR,AAL,DSL Control
802.3 MAC Driver
228
DSL Hardware Driver
LAN Hardware Driver
USB Controller Driver
230
232

Figure 2

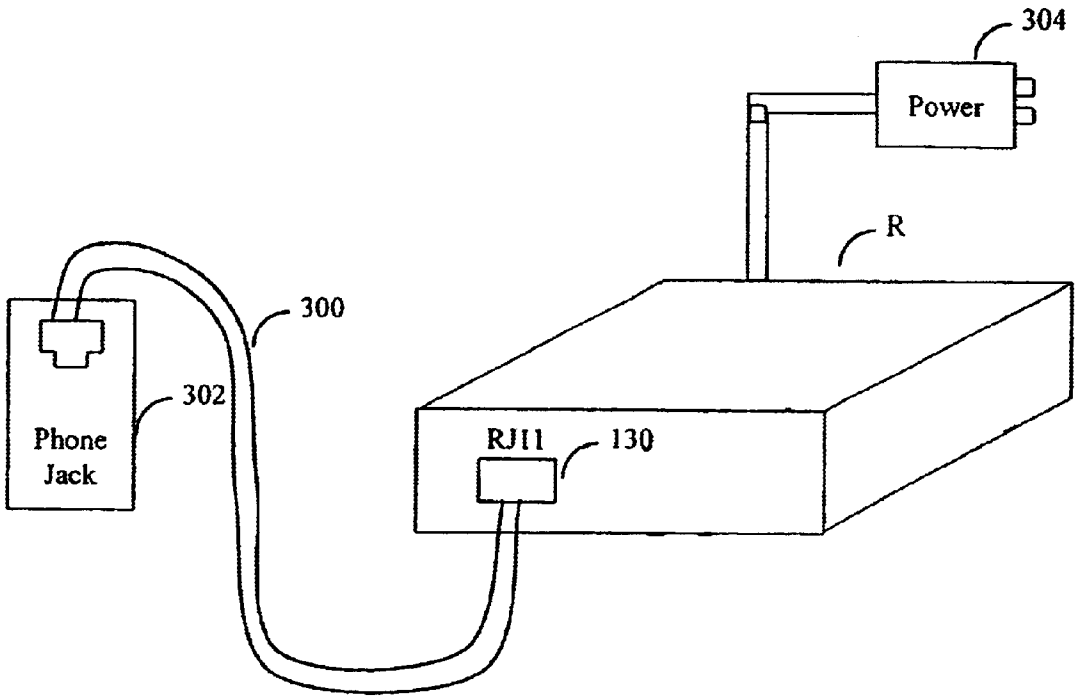


Figure 3

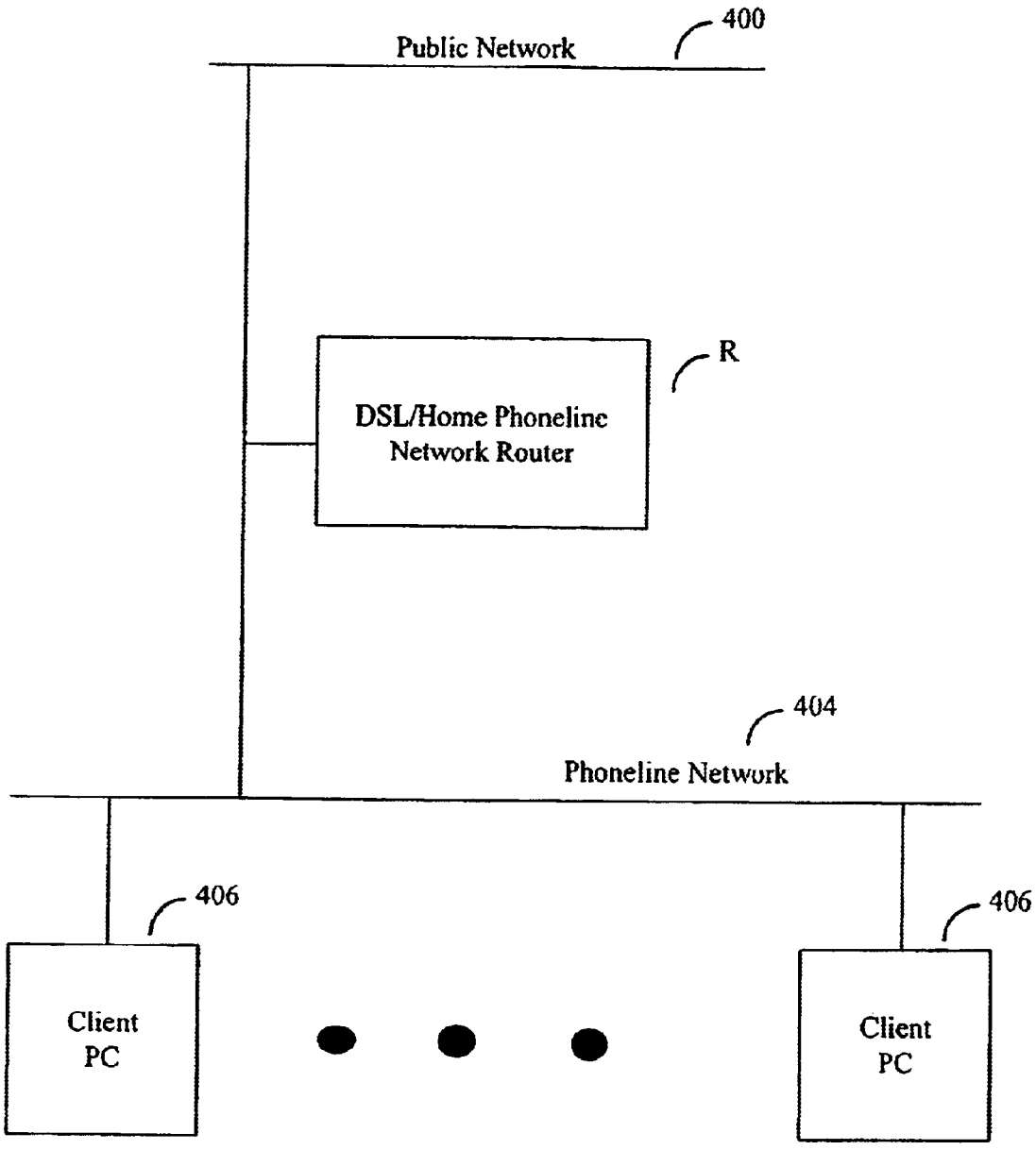

Public Network
400
DSL/Home Phoneline
Network Router
R
404
Phoneline Network
406
406
Client
PC
Client
PC

Figure 4

DIGITAL SUBSCRIBER LINE/HOME PHONELINE NETWORK ROUTER

BACKGROUND

1. Field of the Invention

The present invention generally relates home networking technology and more particularly to a digital subscriber line/home phoneline network router.

2. Description of the Related Art

As home networking continues to emerge, there is a growing need for high-speed connections to rapidly supply digital data within homes. Businesses typically achieve high-speed connections by deploying local area networks (LANs). These networks, however, are not commonly employed in the home due to the cost and complexity of installing new wiring required by traditional LANs.

The Home Phoneline Networking Alliance (Home PNA) has proposed high-speed home networks using a consumer's existing phoneline. Many products such as personal computers (PCs), home gateway computers, cable modems, DSL (Digital Subscriber Line) modems, digital set-top boxes, digital televisions, digital radios, digital cameras, digital telephones and other network appliances stand to benefit from high-speed connections to a home network. Home phoneline networking technology has been designed to ensure compatibility with other communication services within the home, such as voice, ISDN (Integrated Services Digital Network), and DSL data services. Since a home phoneline network is an Ethernet-compatible LAN, phoneline networking technology has leveraged existing Ethernet software and hardware.

Translating, addressing and routing control for home networks has traditionally been managed by home network controllers and/or home gateway computers. In contrast, traditional LANs have typically been managed with network routers. Such network routers include DSL-Ethernet routers and ISDN-Ethernet routers targeted to businesses. These routers have been difficult to install and use.

SUMMARY OF THE INVENTION

Briefly, a digital subscriber line (DSL)/home phoneline network router provides DSL connectivity and home networking support. The router provides a single phone line connection (RJ-11 jack) to access either the Internet or a home phoneline network. In terms of hardware, the router may include a central processing unit, a DSL modem, and a home phoneline networking device (media access controller and home phoneline networking physical interface). In terms of software, the router may include a DSL driver, a local area network (LAN) driver, a media access controller driver, network routing stacks and a real time operating system.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. **1** is a block diagram of an exemplary hardware architecture of a digital subscriber line/home phoneline network router;

FIG. **2** is a diagram of an exemplary software architecture of the digital subscriber line/home phoneline network router of FIG. **1**;

FIG. **3** is an isometric view of the digital subscriber line/home phoneline network router of FIGS. **1** and **2**; and

FIG. **4** is a block diagram of an exemplary home network environment including the digital subscriber line/home phoneline network router of FIGS. **1–3**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Turning now to the drawings, FIG. **1** shows an exemplary hardware architecture for a digital subscriber line (DSL)/home phoneline network router R. The router or bridge R includes a reduced instruction set computer (RISC) central processing unit (CPU) **112** to handle the overall management of the router R. For example, the CPU **112** can handle DSL modem control, ATM (Asynchronous Transfer Mode) segmentation and reassembly (SAR) and other ADSL protocol processing, LAN (Local Area Network) protocol, and communications with a universal serial bus (USB) controller. As an alternative to the CPU **112**, a digital signal processor can be used. The CPU **112** is shown coupled to a Ethernet controller **114** and a DSL modem **120**. The Ethernet controller **114** includes a media access controller (MAC) **118**. Both the Ethernet controller **114** and the MAC **118** may be implemented in other ways. For example, the MAC **118** can be integrated with the CPU **112**. In a disclosed embodiment, the MAC **118** is effectively compliant with the I.E.E.E. 802.3 standard for 10 Mbps Ethernet networking. The MAC **118** is coupled to a 1M8 physical layer device **122**. The 1M8 physical layer (PHY) device **122**, a home phoneline networking physical layer device, is described in the Home Phoneline Networking Alliance (HPNA) 1M8 PHY Specification, Version 1.0. Alternatively, the 1M8 PHY **122** can conform to the upcoming 10 Mbps Home Phoneline Networking Alliance 2.0 Specification. The 1M8 PHY **122** generally enables home networking by allowing Ethernet packets to be transported over standard home telephone wiring using standard Ethernet CSMA/CD (Carrier Sense Multiple Access/Collision Detect) Media Access Control (MAC) procedures as specified in the I.E.E.E. 802.3 standard. The 1M8 PHY **122** generally serves as a home phoneline networking physical interface. The 1M8 PHY **122** and the MAC **118** together generally serve as a home phoneline networking device. An optional USB interface may be designed into the router R as well for host connectivity.

The DSL modem **120** and the 1M8 PHY **122** may both be coupled to a plug-in module **124** containing a DSL analog front end (AFE) **126**, a 1M8 AFE **128** and an RJ-11 jack **130**. More particularly, the DSL modem **120** is coupled to the DSL AFE **126**, and the 1M8 PHY **122** is coupled to the 1M8 AFE **128**. Communication between the 1M8 PHY **122** and the MAC **118** is generally understood in the art. As an alternative to a plug-in configuration, the DSL AFE **126**, 1M8 AFE **128** and RJ-11 jack **130** may be directly integrated into the router R. As an alternative to the RJ-11 jack, other types of customer premise equipment/telephone company interfaces might be used.

By integrating the 1M8 PHY **122**, the 1M8 AFE **128**, the MAC **118**, the DSL modem **120**, and the DSL AFE **126**, the router R provides the appropriate hardware to enable home networking and DSL connectivity. DSL should be understood to refer to any of the technologies in the DSL family, such as symmetric DSL (SDSL), Asymmetric DSL (ADSL), High-Speed DSL (HDSL), and G. Lite. Those skilled will appreciate that there can be variations in configurations for the router R depending on the particular DSL technology

implemented. ADSL is currently the preferred standard in the industry. Further, the router R supports both home networking (PHY) layer functionality and Ethernet (MAC) layer functionality.

The CPU **112** is further coupled to a set of status light emitting diodes (LEDs) and a liquid crystal display (LCD) **102**, a memory **104**, a button interface (I/F) **106**, a flash read only memory (ROM) **108**, a power subsystem **110** and a compact flash slot **100**. The LEDs **102** may include a home phoneline network indicator to indicate active home networking functionality and a DSL indicator to indicate active DSL connectivity.

Referring to FIG. **2**, an exemplary real time software architecture for the router R is shown. The router R is shown including a real time operating system (RTOS) **226**. The RTOS **226** provides functions and services to a number of illustrative software components: software plug-ins **200** for OEM customization, a user interface **202**, a host communications module **204**, a statistics and logging module **206**, caching algorithms **208**, a web server component **210**, a management agent module **212** to support SNMP (Simple Network Management Protocol), a security module **214** to support a firewall and IP (Internet Protocol) source and destination filtering, OSI (Open System Interconnection) layers **5** and **6** (session and presentation) module **216**, a TCP (Transmission Control Protocol)/UDP (User Datagram Protocol)/ICMP module **218**, an IRP and ARP (Address Resolution Protocol) module **220**, an SAR, AAL, and DSL control module **222**, a MAC driver **224**, a DSL hardware driver **228**, a LAN hardware driver **230** and a USB controller driver **232**. These software components which can run on the CPU **112** may be stored in the memory **104** or the flash ROM **108**. Those skilled in the art will appreciate the techniques which might be employed to integrate the illustrated software and drivers within the router R. Use of software such as that illustrated enables the router R to handle bridging, routing, proxy and other related services in a residential environment. Like a typical router, the router R can support full-featured bridging and routing capabilities. Other arrangements of software components or modules to support the router R are possible. The OSI layers 5 and 6 module **216** provides network routing stacks to implement a typical router algorithm such as Network Address Translation (NAT). The web server **204** is used in configuring the CPU **112**, the DSL modem **120** and the MAC **118**.

Referring to FIG. **3**, an exemplary digital subscriber line/home phoneline network router is shown. Power is supplied to the router R through a plug **304**. The router R includes the RJ-11 jack or connector **130** for connection via a phone wire **300** to a wall phone jack **302**. The single phone wire **300**, which handles both DSL connectivity and home phoneline connectivity, allows for ease of installation for the router R. The phone wire **300** serves to connect the DSL AFE **126** to a public network and serves to connect the 1M8 AFE **128** to a phoneline network. The RJ-11 jack **130** serves as both a home phoneline network interface and a DSL interface. As shown in FIG. **1**, the RJ-11 jack couples the DSL AFE **126** and the 1M8 AFE **128**. The router R presents only a single RJ-11 jack **130** to a user. With the single phoneline **300** and the single RJ-11 jack **130**, the router R can handle concurrent DSL connectivity and home phoneline connectivity.

Referring to FIG. **4**, an exemplary home phoneline network environment is shown. This network environment includes the digital subscriber line/home phoneline network router R. The router R is shown coupled to a public network **400** (such as the Public Network) and a phoneline network **404**. The phoneline network **404** is further coupled to multiple client personal computers (PCs) **406**. Packets are transmitted to and from the client PC **406** on the phoneline network **404**. The phoneline network **400** may, for example, be a 1 Mbps home phoneline network or a 10 Mbps home phoneline network effectively compliant with the standards of the Home Phoneline Networking Alliance. Internet access and other services for the client PCs **406** are accomplished through the router R. The clients PCs **406** may connect to the Internet or a remote LAN. In addition, the client PCs **406** can utilize the web server **204** to properly configure the router R. While only client PCs **406** are shown connected to the phoneline network **404**, it should be understood that a variety of network devices (e.g., digital telephones, digital televisions and laptops) may also be connected to the phoneline network **404**. Other configurations of a home phoneline network environment supporting the router R are possible.

It should be understood that the disclosed functionality and structure may be integrated into high speed access products other than a router or bridge. While DSL services are mentioned in connection with the disclosed router, it should be understood that alternatively a router or other high speed access device might support derivative, compliant or similar high speed data services available on the Public Switched Telephone Network.

We claim:

1. A digital subscriber line/home phoneline network router, comprising:

a central processing unit;

a digital subscriber line modem coupled to the central processing unit;

a media access controller coupled to the central processing unit;

a home phoneline networking physical interface coupled to the media access controller;

a digital subscriber line analog front end coupled to the digital subscriber line modem;

a home phoneline networking analog front end coupled to the home phoneline networking physical interface; and

a customer premise equipment/telephone company interface coupled to the digital subscriber line analog front end and the home phoneline networking physical interface,

wherein the media access controller communicates with a home phoneline network via the home phoneline networking physical interface, and

wherein the digital subscriber line analog front end, the home phoneline networking analog front end, and the customer premise equipment telephone company interface are provided on a plug-in card.

2. The router of claim **1**, wherein the customer premise equipment telephone company interface comprises an RJ-11 jack.

3. The router of claim **1** further comprising:

a wire coupled to the customer premise equipment/telephone company interface to support digital subscriber line connectivity and home phoneline connectivity.

4. The router of claim **1**, wherein the home phoneline networking physical interface comprises a home networking 1M8 physical layer device.

5. The router of claim **1**, further comprising:

a universal serial bus controller coupled to the central processing unit.

6. The router of claim 5, the memory comprising:

a media access controller driver.

7. The router of claim 5, the memory comprising:

a web server to configure the central processing unit, digital subscriber line modem and media access controller via computer(s) coupled to the home phoneline networking physical interface.

8. The router of claim 1, further comprising:

a memory containing a digital subscriber line driver and a local area network driver.

9. A home phoneline network environment, comprising:

a phoneline network;

a plurality of computers coupled to a phoneline network;

a public network; and

a digital subscriber line/home phoneline network router coupled to the phoneline network and the public network, the router comprising:

a central processing unit;

a digital subscriber line modem coupled to the central processing unit;

a media access controller coupled to the central processing unit;

a home phoneline networking physical interface coupled to the media access controller; and

a digital subscriber line analog front end coupled to the digital subscriber line modem;

a home phoneline networking analog front end coupled to the home phoneline networking physical layer device; and

a customer premise equipment/telephone company interface coupled to the digital subscriber line analog front end and the home phoneline networking physical interface,

wherein the media access controller communicates with the phoneline network via the home phoneline networking physical interface, and

wherein the digital subscriber line analog front end, the home phoneline network analog front end, and the customer premise equipment/telephone company interface are provided on a plug-in card.

10. The network environment of claim 9, wherein the customer premise equipment/telephone company interface comprises an RJ-11 jack.

11. The network environment of claim 9, the router further comprising:

a wire coupled to the customer premise equipment/telephone company interface to support digital subscriber line connectivity and home phoneline connectivity.

12. The network environment of claim 9, wherein the home phoneline networking physical interface comprises a home networking 1M8 physical layer device.

13. The network environment of claim 9, the router further comprising:

a universal serial bus controller coupled to the central processing unit.

14. The network environment of claim 9, the router further comprising:

a memory containing a digital subscriber line driver, a local area network driver, and network routing stacks.

15. The network environment of claim 14, the memory comprising:

a media access controller driver.

16. The network environment of claim 14, the memory comprising:

a web server to configure the central processing unit, digital subscriber line modem and media access controller via computer(s) coupled to the home phoneline networking physical interface.

17. A home phoneline network high-speed access routing device, comprising:

a central processing unit;

a high speed data service modem means coupled to the central processing unit for establishing high speed data connectivity with a public network;

a media access controller coupled to the central processing unit;

a home phoneline networking physical interface means for communicating with the media access controller and a phoneline network;

a high speed data service analog front end means for communicating with the public network;

a home phoneline networking analog front end means for communicating with the phoneline network; and

a customer premise equipment/telephone company interface means for coupling the high speed data service analog front end means and the home phoneline networking analog front end means,

wherein the media access controller communicates with the phoneline network via the home phoneline networking physical interface, and

wherein the high speed data service analog front end means, the home phoneline network analog front end means, and the customer premise equipment/telephone company interface means are provided on a plug-in card.

18. The routing device of claim 17, further comprising:

a telephone physical connection means for connecting the high speed data service analog front end means to a public network and the home phoneline networking analog front end means to a phoneline network.

* * * * *